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First Quarterly Technical Report 1.0.1,

Analysis and Evaluation of Technical Data
on the
Photochromic and Non-Linear Optical
Properties of Materials

March 1, 1989 ✓

George Mason University

Robert F. Cozzens, Principal Investigator ✓

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Background

The overall goal of this relatively small contractual effort is to provide technical assistance to Dr. Frank Patten (DARPA) in evaluating data on materials, especially polymers, that may be useful in the development of optical limiters for the protection of eyes and electrooptic sensors from exposure to damaging levels of laser radiation. A major task is to assist in the development of a predictive capability in assessing the viability of various protective approaches and to determine the theoretical limitations which may exist in the use of organic materials as optical switches and limiters.

The rate at which optical switches may be activated is limited by the intensity of the activating radiation and the basic process responsible for switching. Phase transitions require milliseconds to seconds to respond, Kerr cells operate in the 10^{-2} to 10^{-7} sec range, molecular reorientations require 10^{-6} to 10^{-10} seconds, and pure electronic transitions take place in the 10^{-8} to 10^{-14} second range. Simply because a given molecular transition takes place rapidly does not mean that, collectively, sufficient molecules can be made to undergo transitions in short enough times to serve as an effective optical switch or limiter. Response times for a light driven device as a whole are controlled not only by the response time of individual molecules but the rate at which photons responsible for switching are absorbed by the system in order to induce switching. At the same time, one must consider whether the transparency of the system under ambient illumination is adequate for its intended use and whether the material can dissipate the absorbed energy without irreversible damage to the system.



Progress to Date

A search of the literature has been initiated in an attempt to gather into one table the magnitude of the non-linear optical properties of various organic materials as a function of molecular structure. The search includes research activities supported by the Federal Government as well as the open literature. A partial list of references currently being documented appear as Appendix A of this report. The next quarterly report should contain a partial table of materials vs. NLO properties. It is anticipated that this table will represent a "living document", continuously updated as the NLO properties of experimental organic materials are reported.

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Frequent conversations have been held with Dr. Frank Patten (DARPA) with regard to the direction of this effort. At his request, initial contact has been made with Dr. Marshal Sparks of BDM Corp. (Calif.). It is anticipated that we will team in developing a model capable of predicting the theoretical limitations which may exist in using various materials as optical switches or limiters in the protection of eyes and sensors. The Principal Investigator attended the two day Technical Steering Committee meeting held in Crystal City, Virginia, 24-25 January 1989. It is anticipated that he will attend the SPIE meeting in late March in Orlando, Florida which will be dedicated to Sensor Protection.

A recent and related synthetic chemistry research effort has been initiated within the Chemistry Department at George Mason University in developing new organic molecules and polymers which may have enhanced non-linear optical properties, especially ladder polymers, including those containing heterocyclic groups.

The Principal Investigator is coordinating his activities with the Chemistry Division of the Naval Research Laboratory in Washington, D. C. in order to avoid duplication of effort and to maximize research efficiency.

APPENDIX A

Technical References
Used In
Development of Table
of
Non-Linear Optical Properties of Organics
As A Function Of
Molecular Structure

To accompany "First Quarterly Technical Report"

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